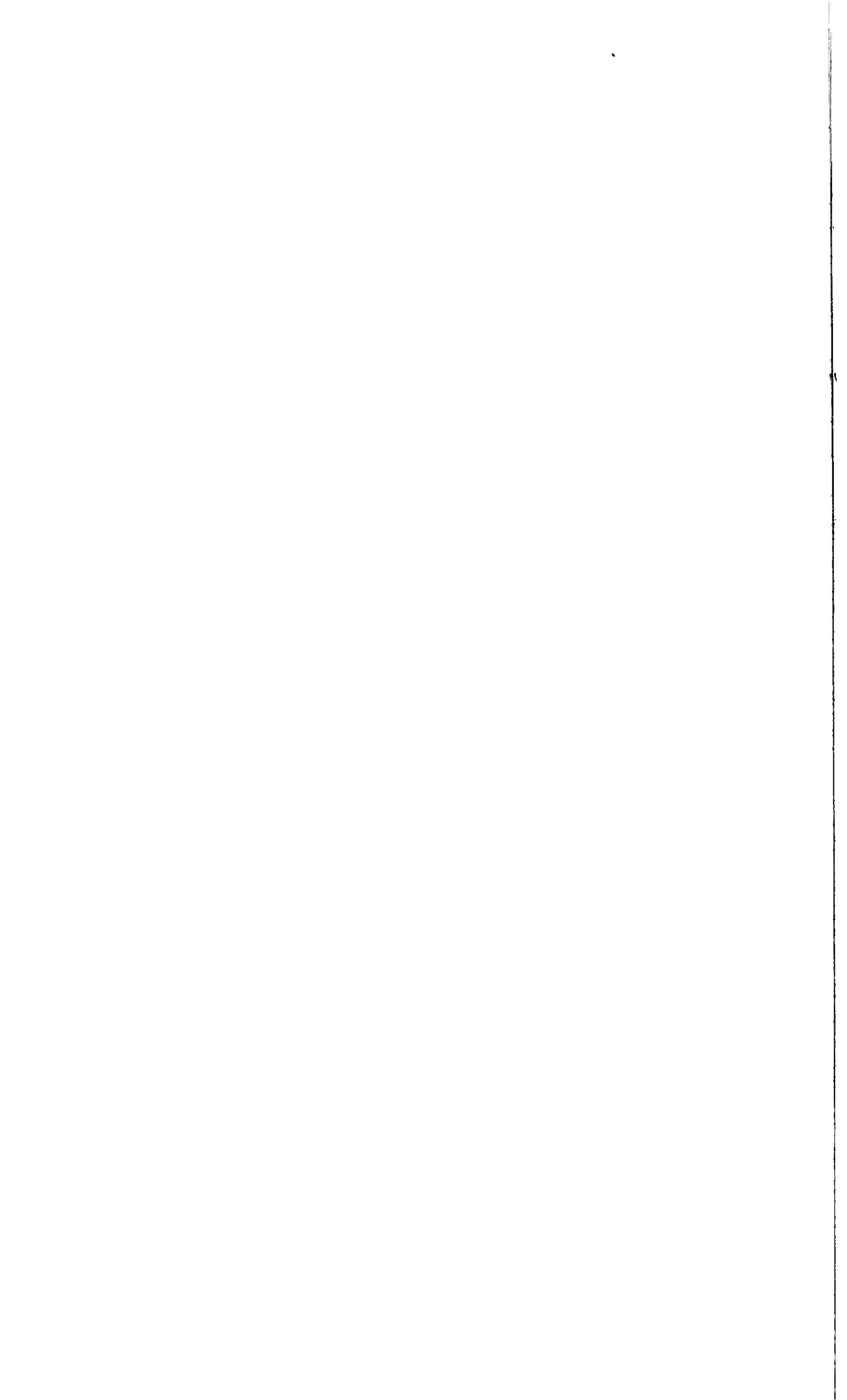


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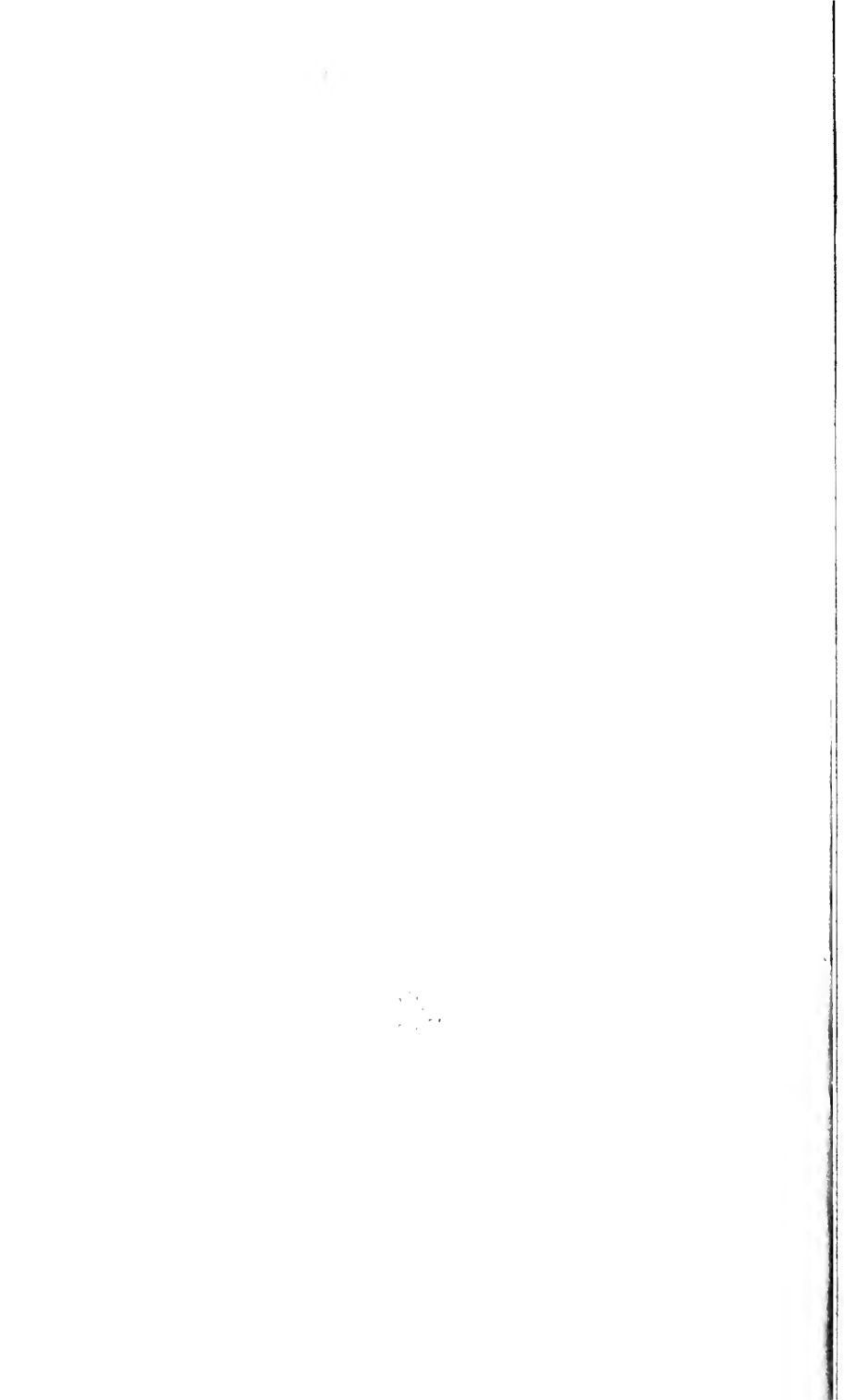


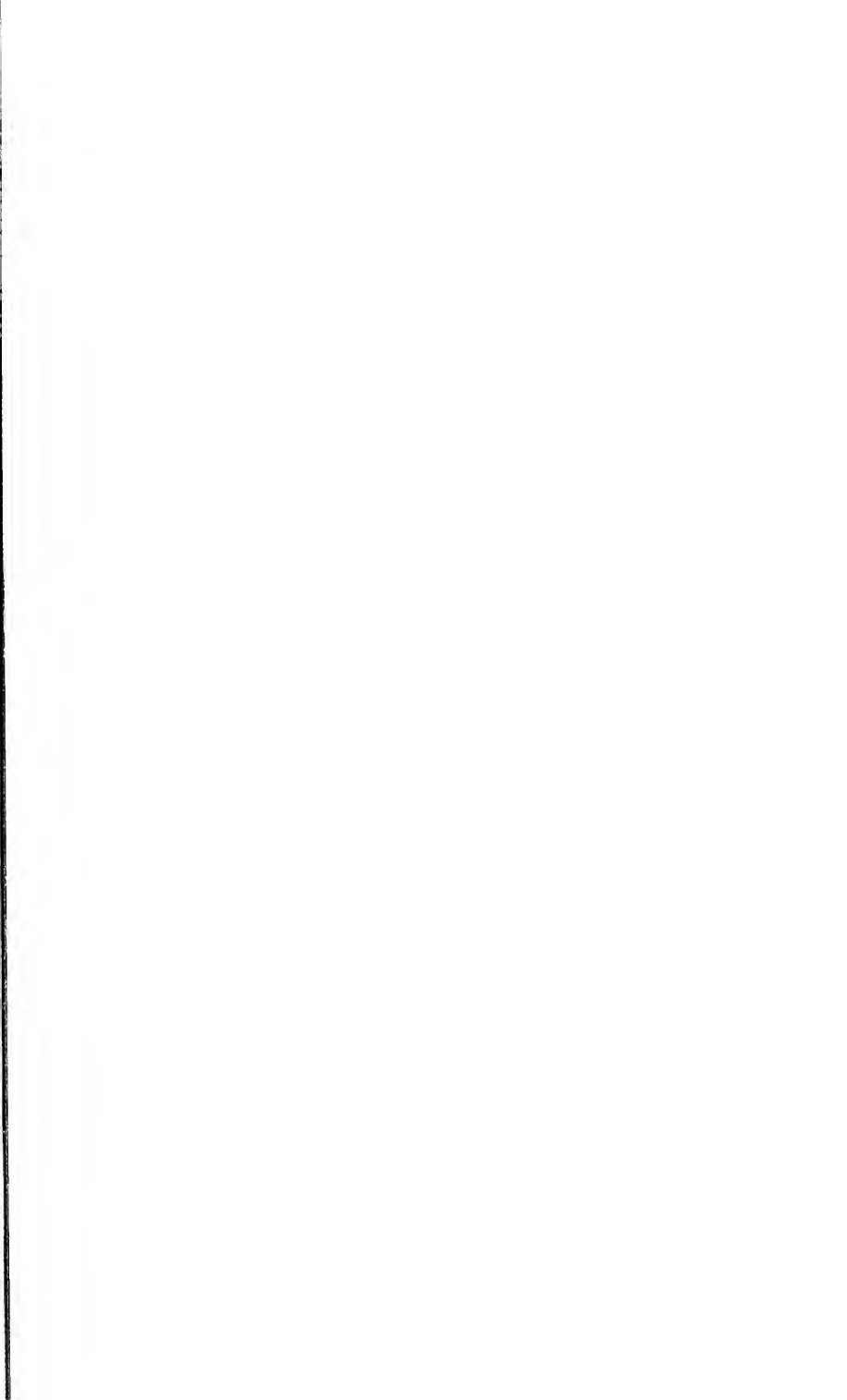
THE RUINED MILL, OR ROUND
CHURCH OF THE NORSEMEN,
AT NEWPORT, RHODE ISLAND,
U.S.A., COMPARED WITH THE
ROUND CHURCH AT CAMBRIDGE
AND OTHERS IN EUROPE

BY

F. J. ALLEN, M.D.

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NEWPORT, RHODE ISLAND, U.S.A.

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NORSEMEN, AT NEWPORT, RHODE ISLAND, U.S.A.,
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By F. J. ALLEN, M.D.

Read November 24, 1919¹.

(Names or numbers in brackets refer to the bibliography
on page 106.)

The city of Newport, Rhode Island, possesses a feature unique in the Western Hemisphere—a venerable ruin, of mediaeval aspect, and having the form of a Norman round church. It is called “the Old Mill,” and is believed to be the building described as “my stone-built wind-mill” in the last will of Benedict Arnold, Governor of the Island, dated December 24, 1677. But while there is no doubt that the building was used as a windmill, its construction is so unusual for a mill and so like that of a Scandinavian round church, that many observers are of opinion that it was built as a church by the Norsemen or Vikings (who had a colony in this part of America in the twelfth and thirteenth centuries), and that Governor Benedict Arnold merely adapted it to the purposes of a mill, believing it to have been built as such.

The matter has been the subject of considerable controversy, and from 1838 onwards various antiquaries and architects have written papers *pro* and *contra*; but the question is still open, and while many persons are quite satisfied that the building was never anything but a windmill of the seventeenth century, others think it more probable that it was primarily a church of the twelfth century.

¹ Since this paper was read, the author has received important information concerning Benedict Arnold, which affects the history of the building. See page 99.

The expression "my stone-built wind-mill," in the will of Benedict Arnold, does not favour either side of the controversy: it is the simplest possible description of the building, and would apply equally to a mill built by himself or to one built by anyone else.

Before entering on the discussion of the question, I may mention that about the year 1840 a skeleton in armour, supposed to be the body of one of the Vikings, was found buried at Fall River, on the mainland close to Rhode Island; and that Longfellow wrote a ballad on the event, describing the building at Newport as the warrior's tower.

I visited Rhode Island in 1880, and made notes and careful drawings of the Old Mill. The building left a deep impression on my mind, so that I have ever since been on the alert for any information or observation that might help to elucidate its origin. In the course of investigation I have noted certain points which seem to me important, but which are not mentioned by any of the writers whose works are within my reach; and it is because of these additional evidences, and because of certain resemblances between the ruin in question and the Round Church at Cambridge, that I think it not inappropriate to lay the subject before this Society.

Rhode Island, *alias* Aquidneck, is a little larger than Jersey, and is situated in the inlet known as Narraganset Bay on the south coast of New England, about 60 miles south of Boston and 160 miles east-north-east of New York. The island is separated from the mainland by a channel which is only about one mile wide at the narrowest. Rhode Island gives its name to the smallest of the States, of which it forms a part. Newport, on the west coast of the island, is its largest town, and had in the early days of the New England colony a considerable trade as a seaport: but in recent times it has developed into a very luxurious watering place, a garden city by the sea; and in one of its public parks the Ruined Mill stands picturesquely among the trees.

The photograph, Plate VI, shows the ruin to be of the shape of the central portion of a twelfth century round church,

from which the surrounding aile or ambulatory has been removed. It consists of eight round columns with semi-circular arches, supporting an upper storey which is quite plain and is remarkable for the barbaric paucity of its windows.

When I visited the building I was struck with two of its characters, firstly its similarity in form and dimensions to the Round Church at Cambridge, and secondly the skill with which the builders, using only unhewn stones, had managed to imitate the contour of the Norman column, its shaft, base and capital.

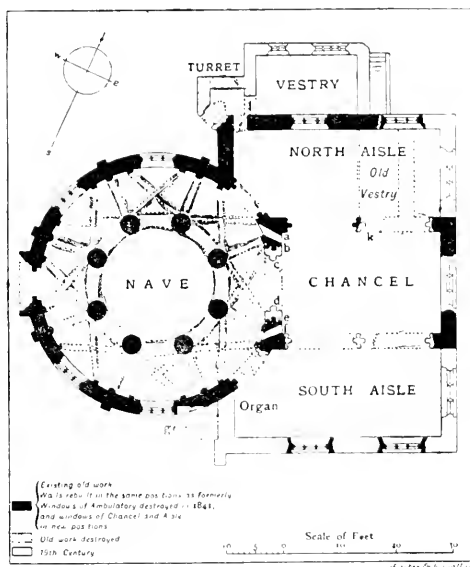


Fig. 1. Plan of the Round Church of the Holy Sepulchre, Cambridge.

Reduced from Atkinson and Clark's *Cambridge Described and Illustrated*, by permission of Messrs Macmillan and Co., and Messrs Bowes and Bowes.

The above fig. 1 shows the plan of the Round Church of the Holy Sepulchre at Cambridge. It will be seen that the circle of eight columns in the plan would answer for either of the two buildings under consideration, but the outer circular wall enclosing the ambulatory does not at present exist at the Newport ruin: whether it formerly existed is a matter for investigation. The chancel at Cambridge is a late addition, replacing a smaller early chancel. Careful digging around the Newport

building might reveal the foundations of a former ambulatory or chancel.

The dimensions of the Newport ruin are remarkably similar to those of our Cambridge church, as the following figures will show :

	Newport	Cambridge
Diameter of central building, excluding ambulatory :		
external	*23 ft. 0 in.	26 ft. 6 in.
internal	+18 „ 4 „	19 „ 6 „
Diameter of columns ...	* 3 „ 2 „	3 „ 6 „
Height of columns ...	+ 8 „ 8 „	8 „ 5 „
„ „ arches ...	+11 „ 2 „	11 „ 0 „
Entire height of building	+26 „ 0 „	about 30 „ 0 „

The figures marked * are from R. G. Hatfield (5); those marked + are from G. C. Mason (6). See bibliography on page 106.

Too much importance must not be attached to this similarity of dimensions. At most it can only mean that such dimensions were convenient, and might be used in many churches.

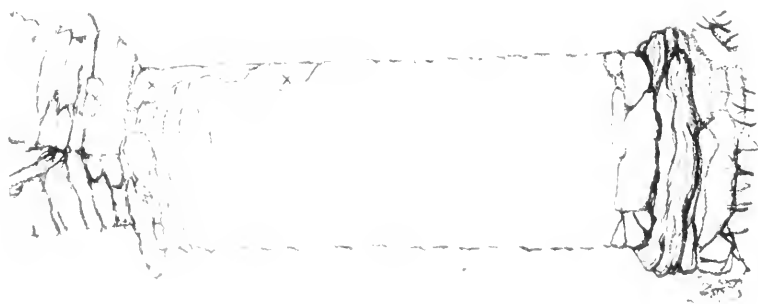
The view of the interior of the Round Church at Cambridge, Plate VII, shows some points in which the two buildings may have resembled or differed from each other. The chief difference is that the Cambridge church follows the English custom, being open from floor to vault, with triforium and clerestory, while the Newport building (if a church) followed the Scandinavian custom, being divided by floors into three storeys.

Some idea of the date of the Newport ruin may be obtained from the study of its masonry, of which the following description is extracted from the notes which I made on the spot, while the illustrations in Plates VIII and IX are reproduced from the drawings which I made at the same time. I regret that the shortness of my visit prevented me from making a more complete series of drawings.

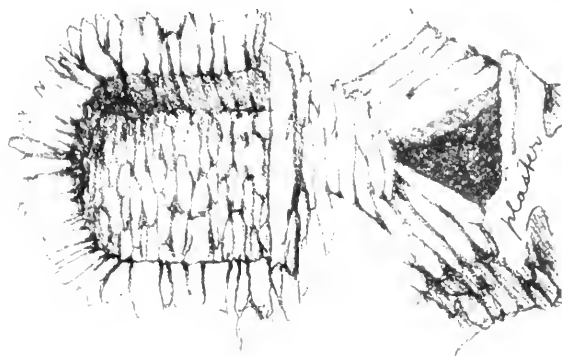
The masonry is extremely rude. I could find in it no hewn stones, though some appeared to have been roughly chipped or broken. The stones were probably picked up from the sea beach, where similar ones were (in 1850) still lying in abundance. The stones used vary much in size, and are generally selected judiciously so as to produce the form required, whether plain



ROUND CHURCH OF THE HOLY SEPULCHRE, CAMBRIDGE.
(*Photograph by F. J. Allen.*)



A. Side view of a column, showing outer and inner imposts.
The crosses indicate remnants of plaster.



B. Inner view of top of a column, showing
inner impost and spring of two arches,
and fireplace in relative position.

wall, arch, base, capital, sill, or lintel. The rude imposts and bases are in most cases each formed of a single large stone. The greater part of the building seems to have been at first covered with plaster, of which many traces still remain, especially some large patches on the inner sides of the columns: it is merely mortar, and not laid on very evenly. The north-east window, and one or two holes or recesses on the interior surface, have been stopped up with red brick since they were built.

Fig. A, on Plate VIII, is the outline of a column seen laterally, with a few of the chief details of masonry sketched in. Note the Norman form of the base and of the abacus or inner impost. There is a curious outer impost at a lower level, which seems obviously intended to support the roof-timbers of the ambulatory. Immediately above the outer impost the wall is recessed or slanted inwards, so as to bring the ends of these timbers nearer to the axis of the column than they would be with an upright wall. The slant is shown in the same illustration (A, on Plate VIII) where it looks like incorrect drawing; but its truth may be confirmed by comparison with the photograph, Plate VI.

The arches are very rudely constructed, the builder being evidently ignorant of the elementary rule, that all the arch-stones must point to the centre from which the arch is struck. On inspecting the arches, or lower portions of arches, in Plates VI, VIII, and IX, it will be seen that the arch-stones do not point to the centre of the arch, the lowest stones being placed too upright. This increases the outward thrust of the arch and causes weakness.

Immediately above each inner impost a triangular hole is left between the lowest stones of the two adjacent arches, as shown in B, Plate VIII. These holes seem to have received the ends of timbers which formed parts of a framework supporting the floor. But the floor itself must be supposed to have been above the tops of the arches, and therefore about 3 ft. above the holes. As the floor had a span of over 18 ft., a strong framework may have been required to support it; and an additional support, in the form of a central column of stone or wood, may have existed formerly.

It is most necessary to realize that these triangular holes are a very abnormal feature. Each of them constitutes a weak spot at a point where the stress is greatest; and the weakness is intensified by the thinning of the wall on the outer side at the same point, as shown in A, Plate VIII. The weak spot, occurring at each of the eight points of greatest stress, must tend to make the building as a whole unstable and liable to collapse under a strain.

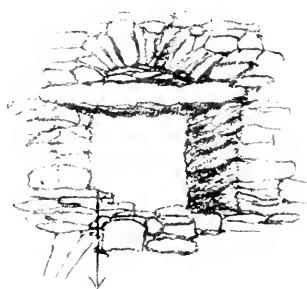
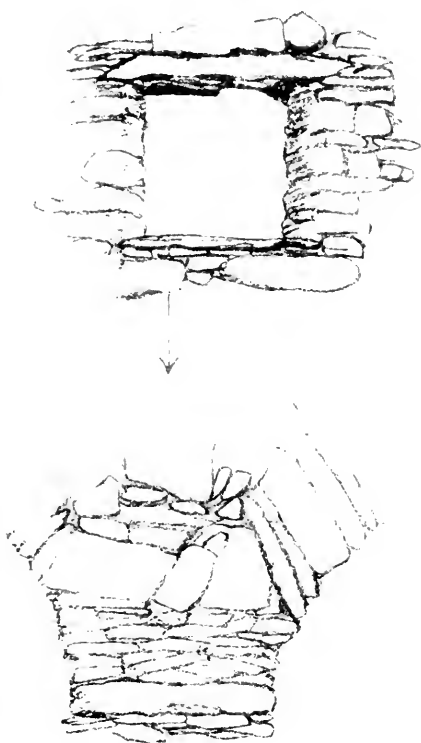
The fireplace, shown in the same drawing, Plate VIII, B, is above the middle of a column on the east side of the building. It has a good hearth-stone, and an arch which is approximately segmental. Some peculiarities in its structure will be described later on. I regret that while trying to represent each stone of the masonry correctly, I happened to get one stone too many in each jamb of the fireplace, and there was not time to make another drawing: one of the least characteristic stones on each side must therefore be discounted. Also in my hurry I drew the fireplace and the arch below, as if seen from two different levels, and therefore not in the same perspective. With these reservations, I believe all the drawings here given are fair representations of the masonry, as may be seen by comparing them with the photograph, Plate VI.

Plate IX, A, shows the outer aspect of one of the columns, with a window in its relative position, not exactly above the middle of the column. In the column the irregular masonry is outlined, also the broad flat stone which forms the outer impost.

There are three windows, all of them small: two are placed unsymmetrically to the arches, as in the instance just mentioned; the third is over the middle of a north-eastern arch. The windows are nearly square, about 2 ft. wide, *splayed both ways*, but chiefly outwards. They are topped with a single stone for a lintel, and only one of them (between the west and south-west arches) has a discharging arch, which is very inadequate or even nugatory (see Plate IX, B). In fact these windows are barbaric not only for their paucity, but also for their small size and rude construction. They resemble the windows in ancient Celtic and Anglo-Saxon buildings; for comparison I give an illustration, Plate IX, C, after Petrie's *Ecclesiastical Archi-*

A

B



C



- A. The Ruin at Newport, R.I. Outer view of a column, showing outer impost, spring of two arches, and a window in relative position.
- B. The Ruin at Newport, R.I. South-west window.
The arrows in A and B point to middle of respective columns.
- C. Window in Ancient Oratory, Kilmalkedar, County Kerry.

ecture of Ireland, (13) of a double-splayed window, built without cement, in the ancient oratory at Kilmalkedar, County Kerry. Such windows are suited rather for a wooden shutter than for glazing.

In addition to the features already mentioned, there are some square recesses, about eight in number, on the inner face of the wall: these may have supported the ends of timbers.

My drawings and notes were made only from the ground level. For want of a ladder and other apparatus, I was unable to make a thorough examination of the building. But several additional details are described in a paper by G. C. Mason, architect, published in the *Magazine of American History* for 1879 (6). The following are some of his most important points. He finds:

(a) That the fireplace is quite certainly a part of the original building, not a later insertion as some have assumed. Its structure is peculiar: internally it has a flat roof, one foot above the crown of the arch; at each end is a flue 5 in. by 8 in. The north flue runs up nearly vertical, while the other flue curves off easily to the south for some distance and then turns upwards with an inclination still to the south. Both flues open out on the face of the wall about 10 in. below the top, and they are each topped with a large projecting stone, evidently to protect the wooden plate of the roof. The flues are of a full and even area throughout.

(b) That there were two floors, one just above the arches, the other at 20 ft. 2 in. from the ground. A flight of stairs led from the lower to the upper floor, as indicated by holes left to receive the ends of treads...to the north of the fireplace. There is a slight set-back of the wall for the upper floor.

(c) That the window-sills are formed of two flat stones, having an interval of four inches between them to receive the wooden window-sill, the ends of which fitted into mortises in the jambs. The edges of the stones next the intervals are square cut.

(d) That the eight columns are on true cardinal points.

As to the materials of which the ruin is composed, Mr Mason says:

(e) That the stone used is laminated slate, mixed with gneiss of local occurrence.

(f) That specimens of mortar taken from the "Old Mill," and likewise from certain buildings constructed in the days of Benedict Arnold, have been analyzed and found to be of the same quality, and composed of shell-lime, sand, and gravel, with flakes of broken slate pounded fine.

(g) That when Governor Arnold's house (with which the "Old Mill," if built by Arnold, would be contemporary) was pulled down, the mortar was found to be extremely tenacious.

But on the other hand I must point out that the mortar of the "Old Mill" is very much perished: it has scaled off the surface and washed out of the joints. This looks as if the mortar of the ruin were either of inferior quality or of greater age. The similarity of composition in the mortars of different ages may be accounted for by the builders in both cases using the materials which were immediately at hand.

The building then, from its structural characters, might possibly have been built by the Norsemen. But how and when did the Norsemen come to Rhode Island?

It is well known that they sailed from Iceland to Greenland. In the Sagas it is related (Rafn, 1 and 2, Palfrey, 4) that in the year 986 a mariner named Bjarne was driven by contrary winds so far west that he sighted a new land. In 1000 a mariner Leif landed, and then sailed further south till he came to a part which he named Vinland (the Land of Vines) because he found grapes growing wild in the woods.....This is believed to have been the coast now known as New England—Massachusetts, Rhode Island, and Connecticut¹.

Other voyages were made to the same part, and a small colony was established. In 1121 Eric, Bishop of Greenland, arrived in Vinland, where he hoped to Christianize the inhabitants, and it is supposed that he fixed his abode there. It is to him that the building of the Round Church on Rhode

¹ Those who know the country will recognise the appropriateness of the name Vinland, for there grape-vines grow wild, as bryony does in northern Europe. F. J. A.

Island is attributed, and it is significant that the date of his arrival, 1121, was about the time when our Cambridge Round Church and many others in Europe were built.

The Norsemen built churches even in Greenland, of which Prof. Rafn gives Illustrations in his *Antiquitates Americanae*, 1845 (2). If in Greenland, why not *a fortiori* in Vinland? And Rhode Island would be the most suitable spot for a sanctuary, because it was protected by a channel of water from the raids of the Indians. Nevertheless it seems that the little colony could not sufficiently defend itself against these enemies, and after about two centuries the residue of the colonists returned to Iceland.

If the circumstantial evidence had been limited to what I have hitherto related, there would have been little apparent reason to doubt that the Rhode Island ruin was of Norse origin. But the track of the evidence was crossed by a false scent, which divided the issue and caused most of the controversy. It happened thus: Governor Benedict Arnold, who called the building "my stone-built wind-mill," had a farm at Newport which he described as "my Lemmington farm." This was supposed to be named after Leamington in Warwickshire, and it was inferred—incorrectly, as will presently be shown,—that Arnold was a Warwickshire man. If Leamington in Warwickshire had been Arnold's early home, he would probably have seen the extraordinary windmill which was built in 1632 at Chesterton, five miles from Leamington, by Sir Edward Peyto, the architect being no less than Inigo Jones. For the photograph of this windmill, shown on Plate X, I am indebted to my friend Mr F. T. S. Houghton of Birmingham. It was supposed that Arnold had been vividly impressed with this windmill in his native county, and had tried to imitate it in building the windmill on his colonial farm.

But more recently it has been discovered that Arnold was not a Warwickshire man. A record of the Arnold family was kept by several members thereof from 1553 to 1776. A copy of it was found in possession of a descendant, and was published in full in 1879 (15). Mr F. A. Arnold, of Providence, Rhode Island, who is also a descendant, has very kindly sent me full information concerning this record, from which it appears that

Benedict Arnold was a son of William Arnold of Ilchester, Somerset, where he was born on the 21st of December, 1615. Together with his parents and other members of the family, and some friends, he sailed from Dartmouth on the 1st of May, 1635, and arrived at Massachusetts Bay on the 24th of June. There is no reason to suppose that Benedict had seen the Chesterton windmill, which was more than a hundred miles from Ilchester. The "Lemington farm" at Newport was probably named after Limington, a village adjoining Ilchester.

Thus, even if we assume that Benedict Arnold built the Newport mill, it is improbable that he imitated the Chesterton one. But as he might possibly have employed a mason who was acquainted with the Chesterton mill, let us see how far the two buildings resemble or differ from each other. Inigo Jones's mill stands on *six* arches, the columns are quadrangular, the bases, imposts, and arch-mouldings are entirely of Italian form. On the other hand the Newport "Old Mill" stands on *eight* arches, the columns are round, and the elementary bases and imposts are as nearly like Norman or Romanesque forms as they can be when formed of unhewn stone. Then the Chesterton mill is a much more solid building: a windmill has to bear great wind-pressure combined with excessive vibration, and Inigo Jones provided against these. His columns and arches are very thick, and the masonry is of *ashlar*, *i.e.* squared stones. But the columns at Newport are comparatively thin and tall, the arches are wrongly constructed, and the whole masonry is of *uncoursed rubble*. The strength of uncoursed rubble is the strength of its mortar; and before the mortar is set hard, such masonry will collapse under moderate stress. I should estimate that mass for mass the stability of ashlar would be about four times as great as that of uncoursed rubble.

Further, I must refer again to the weakness caused by the thinning of the wall, and the presence of a great hole, at each of those points in the Newport building where the strain is greatest, namely at the spring of the arches from the columns. In short, I should expect such a building to be shaken to pieces if used as a windmill within ten years of its erection: I should even hesitate to design a building of that shape and



THE WINDMILL AT CHESTERTON, WARWICKSHIRE.

(Photograph by F. T. S. Houghton.)

material, without buttresses to bear the outward thrust of the arches.

Let us next consider the characteristic features of round churches on the one hand, and of windmills on the other, so as to find in what respects the Newport ruin resembles either of them.

Round churches had been built occasionally from very early

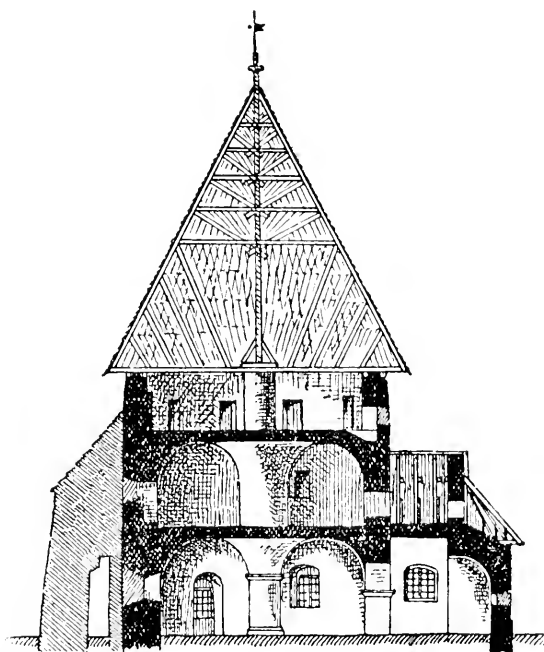


Fig. 2. Round church, Oles-Kirke, Bornholm, section west to east.

Reduced from *Architecture of the Churches of Denmark*, by Major A. Heales, published by Messrs Kegan Paul and Co.

times; but a considerable number of those in North Europe were built under the influence of men who had fought in the Crusades and had seen the Round Church of the Holy Sepulchre at Jerusalem. Beyond the feature of roundness the northern churches do not follow the design of that in Jerusalem, but show many different forms, some extremely simple, others elaborate.

In England there are four Round Churches still in use. Sir

William St John Hope (11) investigated (mostly by excavating the foundations) the remains of six others, and found documentary evidence of the existence of a seventh, making eleven known to have existed, and there may have been more. There are six in North Germany, and one in Holland. In Scandinavia they are rather numerous: Jutland has one, Zealand two, Fünen

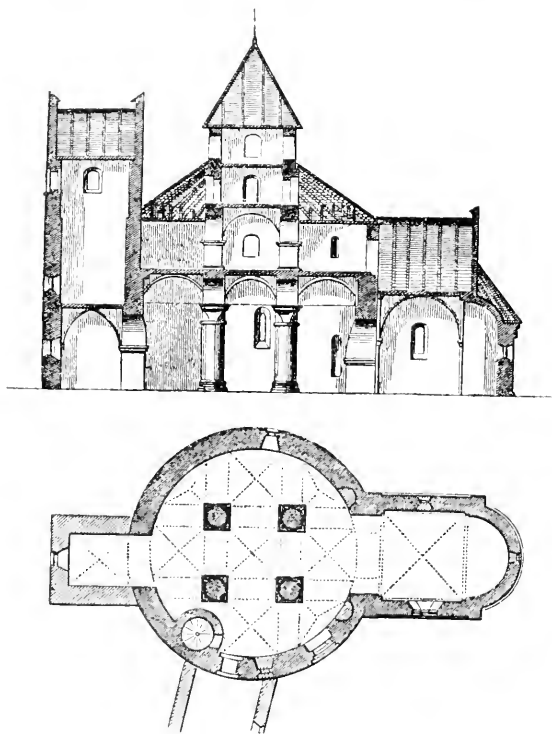


Fig. 3. Round church, Thorsager, Jutland.

Reduced from H. Marryat's *Jutland and the Danish Isles*, by permission of Mr John Murray.

one, and Bornholm four. Eight or more are said to exist in Sweden. (Fergusson, 14.)

Some round churches are encircled with an aisle or "ambulatory," others have none. In England the churches with an ambulatory have their inner circle supported on *eight* or *six* columns with arches; those without an ambulatory have no

columns. In Scandinavia the churches with an ambulatory have *eight* or *six* columns; some of the churches without an ambulatory have *one* central column to support the vault and the upper floors, as at Oles-Kirke, Bornholm (Fig. 2). Intermediate in form between the churches with an ambulatory and those without, are certain churches with *four* columns, a peculiar arrangement of vaulting, and square upper floors and clerestory, as at Thorsager, Jutland (Fig. 3). In most cases the Scandinavian churches have two upper floors (Fig. 2), occasionally three (Fig. 3), forming upper chambers the use of which is not certainly known. These chambers probably held the treasures of the church,—the silver, relics, documents, etc., and afforded lodging for a priest or a custodian; but certain features in their structure make it probable that they were also used as places of refuge in times of danger from enemies. Similar habitable chambers existed in many, perhaps most, of the Anglo-Saxon towers of England: they may be seen in our own Anglo-Saxon tower of St Benet's, also at Brixworth, Barnack, Barton-on-Humber, Deerhurst, and other churches; and they are occasionally met with in churches later than the Anglo-Saxon. In the tower of Irthlingborough church, of the fourteenth century, *the rooms were provided with fireplaces*. (Micklethwaite, 12.) I believe there is no record of the former presence or absence of upper chambers in English round churches: the four round churches still in use retain no evidence of such chambers.

The great majority of windmills, whether of stone, brick, or wood, are built of a conical shape for the sake of stability, the base being sometimes twice or thrice as wide as the top. The early wooden mills, which were turned bodily to face the wind, instead of having a revolving roof, could not be conical; but their wooden frames were so contrived as to bear the strain of wind-pressure and vibration better than a stone or brick structure.

A mill requires three storeys. The middle storey is occupied by the stones and other machinery: the mill is fed from the top storey, and discharges into the lowest.

It will be seen that the Newport ruin resembles the round churches in all essentials. It differs from all windmills, except

that at Chesterton, in standing on columns and arches¹. In possessing two upper storeys it resembles equally a Scandinavian round church or a windmill. To fit it for a windmill the lowest storey must have been enclosed within walls. If an ambulatory formerly existed, it was probably destroyed before the building was used as a mill, and wooden walls were probably constructed inside the circle of arches, as at the Chesterton mill.

The windows are not of the round-headed form that we should expect in a church built by the Norsemen in the twelfth century, neither are they characteristic of the seventeenth century. Plain square openings are found not only in early Celtic buildings (Plate IX, C) but occasionally in rough buildings of almost any period. Nevertheless, the double splay, a device for obtaining the most light through the smallest opening, is generally regarded as a mark of antiquity. In England it was not used after the Norman invasion. The builder of the "Old Mill" at Newport (whether in the twelfth or the seventeenth century) was not skilled in the construction of arches, and may have been glad to avail himself of the flat stones from the sea-shore to make lintels for his windows. Such window openings, closed with wooden shutters, might suffice for a priest's dwelling in the twelfth century; but we should expect to find more and larger windows in a windmill built in the seventeenth century, when glass was abundant, and when houses in the colony were being built with large windows as in England.

Lastly we must consider the fireplace, which Mr Mason regarded as certainly a part of the original building. A fireplace is appropriate for a priest's dwelling, but is hardly admissible in a mill; for the dust of a mill is inflammable, and mills have been burnt or blown up through someone taking a light into them during work: even a winnowing machine has been known to explode in the same way. And if it be urged that the fireplace was for the dwelling room, not the work room, the answer is that a mill is too dusty to be dwelt in. The uninhabitability of a windmill did not escape the notice of Shakespeare: in *King*

¹ I have seen a photograph of a windmill in Antigua, West Indies, with arches in its lowest storey; but the mill is modern, of conical form, and the masonry between the arches is massive.

Henry IV, Part I, Act III, Scene i, Hotspur (referring to Owen Glendower) says :

I'd rather live
With cheese and garlic in a windmill, far,
Than feed on cates, and have him talk to me,
In any summer-house in Christendom.

The only circumstantial evidence in favour of the mill having been built by Arnold, was his supposed origin from Warwickshire and acquaintance with the Chesterton mill; but this has been annulled by the discovery that his home was more than a hundred miles away. There is no other mill from which he could have imitated it, for no other is built on columns. If it were definitely proved that Arnold built the mill, it would raise the problem, Why did he build a windmill in the seventeenth century on the model of a Scandinavian church of the twelfth century? If built by Arnold, the building is a mystery: if built by Bishop Eric, its every feature is accounted for.

The slight resemblance between the Newport ruin and the Chesterton mill may be accidental. The Newport mason may have attempted, with more ingenuity than technical skill, to imitate the round churches he had seen far away in North Europe; whereas Inigo Jones in building the Chesterton mill may have imitated (perhaps unconsciously) the round churches he had seen in Italy.

For my part, I am impressed with the similarity of the Newport building, in all essential features, to the Scandinavian round churches, and its inappropriateness for a windmill. Such a building would probably be shaken to pieces if used as a windmill when new; but it would become safe when the mortar became consolidated by age especially if the interval were, as possibly in this instance, five hundred years.

Nevertheless I consider the evidence indecisive on either side. The matter needs to be re-investigated by someone who is equally acquainted with the building itself, with the round churches of Europe, with the windmill at Chesterton, and with mills in general and their requirements: and the first step in the investigation should be to excavate the ground immediately around the ruin, in search of any remaining foundations of portions of the building that may have been destroyed.

In such excavation the investigator should be guided by the work of Sir William St John Hope, who made important discoveries by excavating the foundations of English round churches (11). It is a matter for regret that Sir William, as he told me, never visited the Old Mill at Newport: his opinion on the building would have been of the greatest possible value.

I am indebted to Mr Clarence S. Brigham, Librarian of the American Antiquarian Society, and to Mr Howard M. Chapin, Librarian of the Rhode Island Historical Society, for valuable information concerning the Ruined Mill and the literature relating to it: also to Mr F. A. Arnold, of Providence, R.I., for very important information from the Arnold family record. My thanks are due to Messrs Macmillan and Co. and Messrs Bowes and Bowes for permission to use Fig. 1, and to Mr John Murray for permission to use Fig. 3. Further, I have had the privilege of examining a large number of photographs of windmills, English and foreign, belonging to the late Mr H. M. J. Underhill of Oxford, and mostly taken by himself in the course of a careful study which he made of their structure.

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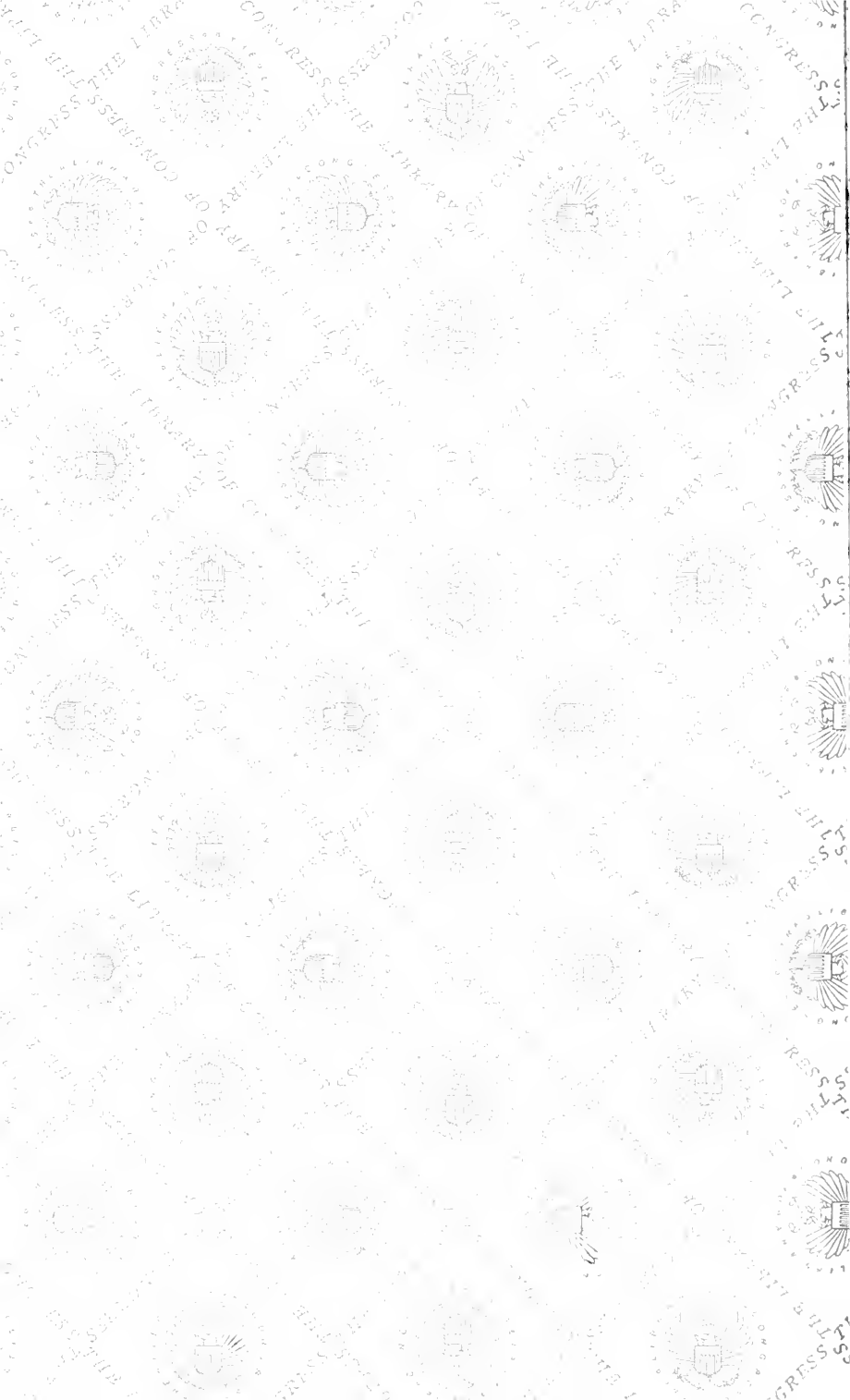
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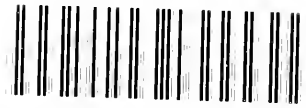
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